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Title:

BOOSTING CIRCUIT

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## **BOOSTING CIRCUIT**

### **BACKGROUND OF THE INVENTION**

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#### **Field of the Invention**

The present invention relates to a boosting circuit, and more particularly, to a boosting circuit capable of preventing giving stress to a cell due to a high voltage applied to word lines of the cell, preventing unnecessary consumption of current and securing the read-out margin, wherein a first boosting means and a second boosting means are precharged with a first potential in a standby mode, and the cell current of the flash memory cell is varied according to a boosting potential of the first boosting means in a read-out mode, whereby the output of a flash memory cell sensing circuit unit is changed and the second boosting means is thus boosted to a third potential or a fourth potential.

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#### **Background of the Related Art**

In order to read out the status of cells in flash memory devices for low voltage, it is required that a voltage higher than the operating voltage be applied to the word lines of the cells. For this, a method of boosting the operating voltage to produce a voltage higher than the operating voltage has been employed. If the operating voltage is boosted twice when the operating supply power of the flash memory cell for low voltage is about 1.8 ~ 2.4V, the boosting voltage is about 4 ~ 5.4V or higher. If the boosting voltage of

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over 5.5V is applied to the word lines, however, it is almost same to a program verification voltage of about 6V. Due to this, there are problems that the read-out margin could not be secured and the lifetime of the cell is shortened due to stress applied thereto.

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### **SUMMARY OF THE INVENTION**

Accordingly, the present invention is contrived to substantially obviate one or more problems due to limitations and disadvantages of the related art, and an object of the present invention is to provide a boosting circuit for  
10 producing a boosting voltage by which a read-out margin could be sufficiently secured.

Another object of the present invention is to provide a boosting circuit capable of sufficiently securing the read-out margin and preventing stress from being applied to the cell, using the flash memory cell to control the boosting  
15 voltage.

The boosting circuit according to the present invention is characterized in that it comprises a reference voltage generating circuit unit for generating a reference voltage according to an address transition detection signal that is delayed by a given time, a first boosting means for outputting a given boosting  
20 voltage according to the address transition detection signal and an inverted signal thereof, a sensing circuit for sensing a flash memory cell according to the reference voltage and the boosting voltage of the first boosting means, wherein the output signal of the sensing circuit is changed depending on the boosting voltage of the first boosting means applied to a gate terminal of the

flash memory cell, a switching circuit for applying the boosting voltage of the first boosting circuit or the power supply voltage depending on the boosting voltage of the first boosting circuit and the output signal of the sensing circuit, and a second boosting means for supplying the power supply voltage to an output terminal according to the address transition detection signal, wherein the second boosting means is boosted according to the boosting voltage of the first boosting circuit or the power supply voltage to output the boosting voltages of two levels to the output terminal.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

The above and other objects, features and advantages of the present invention will be apparent from the following detailed description of the

preferred embodiments of the invention in conjunction with the accompanying drawings, in which:

FIG.1 illustrates a boosting circuit according to the present invention;

FIG. 2 is a circuit diagram for illustrating one embodiment of an address transition detection signal delay circuit applied to the boosting circuit of the present invention;

FIG. 3 is a circuit diagram for illustrating one embodiment of a reference voltage generator applied to the boosting circuit of the present invention; and

FIG. 4 is a circuit diagram for illustrating one embodiment of a switching means applied to the boosting circuit of the present invention.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, in which like reference numerals are used to identify the same or similar parts

Referring to FIG.1, a boosting circuit according to the present invention will be below described in detail.

A reference voltage generating circuit unit **11** comprises an address transition detection signal delay circuit **101** for delaying the address transition detection signal **ATD** by a given time and logically combining it, and a reference voltage generating circuit **102** for generating the reference voltage

according to the output signal of the address transition detection signal delay circuit **101**.

A first boosting means **12** serves to boost a first node **Q11** to a given potential by means of the address transition detection signal **ATD** and the address transition detection signal **ATD** delayed through first ~ third inverters **I11 ~ I13**. The first boosting means **12** is constructed as follows.

A first PMOS transistor **P11** driven by the potential of a second node **Q12** is connected between the power supply terminal **Vcc** and the first node **Q11**. A first NMOS transistor **N11** driven by the address transition detection signal **ATD** is connected between the second node **Q12** and the ground terminal **Vss**. A second PMOS transistor **P12** driven by the address transition detection signal **ATD** is connected between the second node **Q12** and the first node **Q11**. A first capacitor **C11** and a second NMOS transistor **N12** are serially connected between the first node **Q11** and the ground terminal **Vss**. At this time, the first capacitor **C11** is charged according to the address transition detection signal **ATD** delayed through the first ~ third inverters **I11 ~ I13** and the second NMOS transistor **N12** is driven according to the address transition detection signal **ATD**. Also, wells of each of the first and second PMOS transistors **P11** and **P12** are connected to the first node **Q11**, respectively.

A flash memory cell sensing circuit unit **13** is driven according to a reference voltage **VREF** and the potential of the first node **Q11**. Also, the potential of the output voltage of the sensing circuit unit **13** is controlled by the potential of the first node **Q11** applied to the gate of the flash memory cell

**M11**. The circuit unit **13** is constructed as follows. A third PMOS transistor **P13** the gate terminal of which is connected to the ground terminal **Vss** is connected between the power supply terminal **Vcc** and the third node **Q13**. A third NMOS transistor **N13** driven by the reference voltage **VREF** and a flash memory cell **M11** the cell current of which is controlled by the potential of the first node **Q11** are serially connected between the third node **Q13** and the ground terminal **Vss**. At this time, the flash memory cell **M11** keeps the threshold voltage from which UV is erased, for example 2V.

A switching circuit unit **14** serves to transfer the potential of the first node **Q11** or the power supply voltage **Vcc** to a fourth node **Q14** according to the potential of the third node **Q13** being the output of the flash memory cell sensing circuit unit **13** and the potential of the first node **Q11**. The unit **14** is constructed as follows. A first switching means **103** functions to output the potential of the first node **Q11** or a voltage of a Low level according to the output signal of the fourth inverter **I14** that inverts the potential of the third node **Q13**. Also, a fourth PMOS transistor **P14** is connected between the first node **Q14** and the fourth node **Q14** and is driven by the output signal of the first switching means **103**. Meanwhile, a second switching means **104** serves to output the potential of the first node **Q11** or a voltage of a Low level according to the potential of the third node **Q13** that is delayed by fourth and fifth inverters **I14** and **I15**. A fifth PMOS transistor **P15** is connected between the power supply terminal **Vcc** and the fourth node **Q14** and is driven by the output signal of the second switching means **104**. At this time, the well

of the fourth PMOS transistor **P14** is connected to the first node **Q11** and the well of the fifth PMOS transistor **P15** is connected to the fourth node **Q14**.

A second boosting means **15** functions to output the power supply voltage **Vcc** or a boosting voltage to an output terminal **VBOOT** by means of the address transition detection signal **ATD** and the fourth node **Q14**. The second boosting means **15** is constructed as follows. A sixth PMOS transistor **P16** driven by the potential of a fifth node **Q15** is connected between the power supply terminal **Vcc** and the output terminal **VBOOT**. A fourth NMOS transistor **N14** driven by the address transition detection signal **ATD** is also connected between the fifth node **Q15** and the ground terminal **Vss**. A seventh PMOS transistor **P17** driven by the address transition detection signal **ATD** is connected between the fifth node **Q15** and the output terminal **VBOOT**. Further, a second capacitor **C12** and a fifth NMOS transistor **N15** are serially connected between the output terminal **VBOOT** and the ground terminal **Vss**. At this time, the second capacitor **C12** is charged with the potential of the fourth node **Q14** and the fifth NMOS transistor **N15** is driven by the address transition detection signal **ATD**. Wells of sixth and seventh PMOS transistors **P16** and **P17** are each connected to the output terminal **VBOOT**.

A method of driving the boosting circuit according to the present invention will be now described.

In a standby mode, the address transition detection signal **ATD** is applied with a Low level. If the address transition detection signal **ATD** is applied with the Low level, the first and second NMOS transistors **N11** and



**N12** in the first boosting means **12** are turned off and the second PMOS transistor **P12** is turned on. Thus the potential of the first node **Q11** becomes same to that of the second node **Q12**. However, the address transition detection signal **ATD** of the Low level is inverted to a High level through the first ~ third inverters **I11 ~ I13** and the first capacitor **C11** is charged by the potential of the High level, whereby the first node **Q11** keeps the first potential( $\alpha$ ). Accordingly, the second node **Q12** that keeps the potential same to the first node **Q11** keeps the potential of the first potential( $\alpha$ ). Due to this, the first PMOS transistor **P11** is turned off.

10        Meanwhile, the reference voltage generating circuit unit **11** having the address transition detection signal delay circuit **101** for delaying the address transition detection signal **ATD** by a given time and the reference voltage generating circuit **102** for generating the reference voltage according to the output signals of and the address transition detection signal delay circuit **101**

15        outputs the reference voltage **VREF** of a Low level. Accordingly, as the third NMOS transistor **N13** is turned off, the third node **Q13** of the flash memory cell sensing circuit **13** keeps the High level. The first switching means **103** of the switching circuit unit **14** outputs a signal of a Low level and the second switching means **104** outputs a signal of the High level, by means of the

20        potential of the third node **Q13** keeping the High level. Accordingly, the fifth PMOS transistor **P15** is turned off and the fourth PMOS transistor **P14** is turned on. Therefore, the potential of the first node **Q11** is transferred to the fourth node **Q14** and the second capacitor **C12** is thus charged with this potential, thereby precharging the output terminal **VBOOT** with the first

potential( $\alpha$ ). At this time, as the address transition detection signal **ATD** is applied with a Low level, the second boosting means **15** operates same to the first boosting means **12**. Thus, the output terminal **VBOOT** keeps the first potential( $\alpha$ ) same to the first node **Q11** and the fourth node **Q14**.

5        In a read-out mode, the address transition detection signal **ATD** is applied with a High level. If the address transition detection signal **ATD** of the High level is applied, the first and the second NMOS transistors **N11** and **N12** in the first boosting means **12** are turned on and the second PMOS transistor **P12** is turned off. Therefore, the second node **Q12** becomes a Low  
10    level and the first PMOS transistor **P11** is then turned on by the potential of the second node **Q12** that keeps the Low stat, so that the power supply voltage **Vcc** is supplied to the first node **Q11**. Accordingly, the first node **Q11** that was previously precharged with the first potential( $\alpha$ ) keeps the second potential ( $V_{cc} + \alpha$ ).

15        Meanwhile, the reference voltage generating circuit unit **11** having the address transition detection signal delay circuit **101** for delaying the address transition detection signal **ATD** and the reference voltage generating circuit **102** for generating the reference voltage according the output signal of the address transition detection signal delay circuit **101** outputs the reference  
20    voltage **VREF** of a High level. Accordingly, as the third NMOS transistor **N13** is turned on, the potential of the third node **Q13** in the flash memory cell sensing circuit **13** is decided depending on the voltage applied to the gate of the flash memory cell **M11**. However, if the first node **Q11** has about 2.5 ~ 3.5V when the first node **Q11** has a given voltage applied to the gate of the

flash memory cell **M11**, for example the power supply voltage **Vcc** has 1.7~2.6V, the flash memory cell sensing circuit **13** determines that the flash memory cell **M11** has been programmed. Due to this, the third node **Q13** keeps the High level. In other words, as the cell current of the flash memory cell **M11** is varied according to the voltage applied to the gate of the flash memory cell **M11**, the potential of the third node **Q13** is varied according to the cell current. Also, as the potential of the third node **Q13** keeps the High level, the potential is inverted to a Low level via the fourth inverter **I14** and is then inverted to a High level via the fifth inverter **I15**. Accordingly, the first switching means **103** outputs a signal of the Low level and the second switching means **104** outputs a signal of the High level. Therefore, the fourth PMOS transistor **P14** is turned on and the fifth PMOS transistor **P15** is turned off. Also, the potential of the first node **Q11** that keeps the second potential ( $V_{cc}+\alpha$ ) is supplied to the fourth node **Q14** through the fourth PMOS transistor **P14**. The second capacitor **C12** is thus charged by the potential of the fourth node **Q14** that keeps the second potential ( $V_{cc}+\alpha$ ). Meanwhile, as the address transition detection signal **ATD** is applied with the High level, the second boosting means **15** operates same to the first boosting means **12**. Thus, the power supply voltage **Vcc** is supplied to the output terminal **VBOOT**. Therefore, the output node **VBOOT** is applied to the power supply voltage **Vcc** with it precharged with the first potential( $\alpha$ ). Further, as the second capacitor **C12** is charged with the second potential ( $V_{cc}+\alpha$ ), it keeps a third potential ( $2V_{cc}+2\alpha$ ).

Meanwhile, , if the first node **Q11** has about  $3.6 \sim 3.9V$  when the first node **Q11** has over a given voltage applied to the gate of the flash memory cell **M11**, for example the power supply voltage **Vcc** has  $1.7 \sim 2.6V$ , the flash memory cell sensing circuit **13** determines that the flash memory cell **M11** has been erased. Thus, the third node **Q13** keeps a Low level. As the potential of the third node **Q13** keeps the Low level, the potential is inverted to a High level via the fourth inverter **I14** and is then inverted to a Low level via the fifth inverter **I15**. Accordingly, the first switching means **103** outputs a signal of the High level and the second switching means **104** outputs a signal of the Low level. Therefore, as the fourth PMOS transistor **P14** is turned off and the fifth PMOS transistor **P15** is turned on and the power supply voltage **Vcc** is thus supplied to the fourth node **Q14**, the second capacitor **C12** is charged by the power supply voltage **Vcc**. Meanwhile, as the address transition detection signal **ATD** is applied with the High level, the second boosting means **15** operates same to the first boosting means **12**. Thus, the power supply voltage **Vcc** is supplied to the output terminal **VBOOT**. Accordingly, the output node **VBOOT** is applied to the power supply voltage **Vcc** with it precharged with the first potential( $\alpha$ ). Further, as the second capacitor **C12** is charged with the potential of the power supply voltage **Vcc**, it keeps a fourth potential ( $2V_{cc}+\alpha$ ).

As described above, in the boosting circuit according to the present invention, the first boosting means and the second boosting means are precharged with the first potential( $\alpha$ ) in the standby mode and the first boosting means is boosted with the second potential ( $V_{cc}+\alpha$ ) in the read-out

mode. At this time, the cell current of the flash memory cell is changed according to the boosting potential of the first boosting means, thus changing the output of the flash memory cell sensing circuit. Thereby the second boosting means is boosted with the third potential ( $2V_{cc}+2\alpha$ ) or the fourth potential ( $2V_{cc}+\alpha$ ).  
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FIG. 2 illustrates one embodiment of the address transition detection signal delay unit applied to the boosting circuit according to the present invention.

A first resistor **R21** and a first PMOS transistor **P21** driven by the address transition detection signal **ATD** are connected between the power supply terminal **Vcc** and the first node **Q21**. A first NMOS transistor **N21** driven by the address transition detection signal **ATD** is connected between the first node **Q21** and the ground terminal **Vss**. The first PMOS transistor **P21** and the first NMOS transistor **N21** constitute the first inverter **I21**. A second resistor **R22** and a plurality of capacitors **C21 ~ C23** are connected to the first node **Q21**. The potential of the first node **Q21** is inverted by the second inverter **I22**. A NOR gate **21** logically combines the output signal of the second inverter **I22** and the address transition detection signal **ATD**. Thereafter, the output signal of the NOR gate **21** is inverted by the third inverter **I23** and is then outputted as a delayed address transition detection signal **DELAY\_ATD**.  
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A method of driving the address transition detection delay circuit applied to the boosting circuit constructed above according to the present invention will be below described.

If an address is shifted, it is detected and the address transition detection signal **ATD** is applied with a High level. Also, the address transition detection signal **ATD** of the High level is delayed through the first and second inverters **I21** and **I22**. The address transition detection signals **ATD** delayed through the first and second inverters **I21** and **I22** and the address transition detection signals **ATD** that have not been delayed are logically combined in the NOR gate **21** and are then outputted as a Low level. Further, a signal of the Low level is inverted to the High level by the third inverter **I23**, so that the output signal **DELAY\_OUT** is outputted.

10        FIG. 3 illustrates one embodiment of the reference voltage generator applied to the boosting circuit according to the present invention.

A first PMOS transistor **P31** driven by the output signal of the address transition detection delay circuit, i.e., a signal resulting from the delayed address transition detection signal **DELAY\_ATD** inverted through the first inverter **I31** is connected between the power supply terminal **Vcc** and the output terminal **VREF**. A first NMOS transistor **N31** is connected between the output terminal **VREF** and a first node **Q31**. A second NMOS transistor **N32** is connected between the first node **Q31** and the ground terminal **Vss**. A third NMOS transistor **N33** driven by the potential of the first node **Q31** and a fourth NMOS transistor **N34** driven by the output signal of the first inverter **I31** are connected in parallel between the output terminal **VREF** and the ground terminal **Vss**. Meanwhile, the first and second NMOS transistors **N31** and **N32**, which are serially connected, and the third NMOS transistor

**N33** are connected in parallel. Also, the fourth NMOS transistor **N34** is connected in parallel to the first and second NMOS transistors **N31** and **N32**.

A method of driving the reference voltage generator constructed above will be now described.

5           What an address is shifted is detected. The address transition detection signal is thus inputted with a High level. Accordingly, if the address transition detection delay signal **DELAY\_ATD** is inputted with the High level, the address transition detection delay signal **DELAY\_ATD** is inverted to a Low level by the first inverter **I31**, thus turning on the first PMOS transistor  
10   **P31** and turning off the fourth NMOS transistor **N34**. Therefore, the power supply voltage **Vcc** is applied to the output terminal **VREF** via the first PMOS transistor **P31**. At this time, the potential of the output terminal **VREF** is determined by the first and second NMOS transistors **N31** and **N32**, which are serially connected, and the third NMOS transistor **N33** that are connected in  
15   parallel to the NMOS transistors **N31** and **N32**. In other words, the first NMOS transistor **N31** is turned on according to the potential of the output terminal **VREF** that keeps the High level, thus supplying a voltage to the first node **Q31**. Further, the second and third NMOS transistors **N32** and **N33** are also turned on by the potential of the first node **Q31**. Accordingly, the  
20   potential of the output terminal **VREF** is decided by the NMOS transistors **N31**, **N32** and **N33**.

FIG. 4 illustrates one embodiment of the first and second switching means applied to the boosting circuit according to the present invention.

A first PMOS transistor **P41** driven by the potential of the output terminal **OUT** is connected between the power supply input terminal **VPPI** to which the boosting voltage is inputted, and a first node **Q41**. A first NMOS transistor **N41** driven by an input signal **IN** is connected between the first node  
5 **P41** and the ground terminal **Vss**. A second PMOS transistor **P42** driven by the potential of the first node **Q41** is connected between the power supply input terminal **VPPI** and the output terminal **OUT**. A second NMOS transistor **N42** driven by the output signal of a first inverter **I41** for inverting the input signal **IN** is connected between the output terminal **OUT** and the  
10 ground terminal **Vss**. At this time, the input signal **IN** is an inverted signal of the output of the sensing circuit **13** in case of the first switching means **103** and a delayed signal of the sensing circuit **13** in case of the second switching means **104**.

A method of driving the switching means constructed above according  
15 to the present will be now described.

If the input signal **IN** is inputted with a Low level, the first NMOS transistor **N41** is turned off. The input signal **IN** is then inverted to a High level via the first inverter **I41**, thus turning on the second NMOS transistor **N42**. Accordingly, the potential of the output terminal **OUT** becomes a Low  
20 level by the second NMOS transistor **N42** that was turned on. Thereby, the first PMOS transistor **P41** is turned on. Therefore, as the input voltage **VPPI** is applied to the first node **Q41**, the first node **Q41** keeps the High level and the second PMOS transistor **P42** is thus turned off. Thus, the output terminal **OUT** keeps the Low level.



If the input signal **IN** is inputted with a High level, the first NMOS transistor **N41** is turned on. The input signal **IN** is then inverted to a Low level via the first inverter **I41**, thus turning off the second NMOS transistor **N42**. The potential of the first node **Q41** becomes a Low level by the first  
5 NMOS transistor **N41** that was turned on. Due to this, the second PMOS transistor **P42** is turned on. Accordingly, the input voltage **VPPI** is applied to the output terminal **OUT** via the second PMOS transistor **P42** and the output terminal **OUT** keeps the potential of the input voltage **VPPI**.

As mentioned above, according to the present invention, in the standby  
10 mode, the first boosting means and the second boosting means are precharged with the first potential and in the read-out mode, the first boosting means is boosted with the second potential. The cell current of the flash memory cell is varied according to the boosting potential of the first boosting means, thus changing the output of the flash memory cell sensing circuit. Thereby, the  
15 second boosting means is boosted with the third potential or the fourth potential.

Therefore, the present invention has advantageous effects that it can prevent stress from being applied to the word lines of the cell due to a high voltage applied to the word lines, prevent unnecessary consumption of current  
20 and secure the read-out margin.

The forgoing embodiments are merely exemplary and are not to be construed as limiting the present invention. The present teachings can be readily applied to other types of apparatuses. The description of the present invention is intended to be illustrative, and not to limit the scope of the claims.

Many alternatives, modifications, and variations will be apparent to those skilled in the art.